HETA 87-411-1972
JUNE 1989
NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA

NIOSH INVESTIGATORS
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I. SUMMARY

In September 1987, the National Institute for Occupational Safety and Health received a request from the Medical Department of the U.S. Naval Weapons Support Center, Crane, Indiana, to evaluate complaints of sore throat, headache, and fatigue in two buildings on the site. The first area of concern was Building 121, a facility where electronic component fabrication, repair, and testing are performed. The second area of concern was Building 2516, a general office building. Both buildings have been evaluated extensively by the staff industrial hygienists, and no cause for the symptoms had been determined. Additionally, Building 41, a non-complaint building where soldering operations are performed, was included as a referent building for determining exposure levels associated with soldering operations.

On June 7, 1988, industrial hygiene monitoring was performed using both personal breathing zone and area sampling for metal fumes on or near workers performing soldering operations. Area sampling for formaldehyde, carbon dioxide, and hydrocarbons was also performed and temperature and humidity measurements were made. Wipe samples for heavy metals were obtained from the surface of several soldering work stations in Building 121.

Industrial hygiene sampling for all buildings surveyed revealed the following air concentration ranges: carbon dioxide from 600 to 1500 ppm (parts per million), with ambient outdoor levels ranging from 300 to 350 ppm; and formaldehyde from 0.02 to 0.04 ppm. Trace amounts of various organic solvents were detected and wipe samples at several workstations indicated contamination with various amounts of aluminum, calcium, copper, iron, magnesium, lead, nickel, sodium, tin, and zinc.

Medical questionnaires showed a high prevalence of self-reported allergies in both Buildings 121 and 2516. Thermal comfort complaints were noted by 46% of the workers in Building 121 and 13% of the employees in Building 2516. While workers in both buildings reported a high prevalence of symptoms such as headache, nausea, sneezing, and eye irritation, no specific etiology was identified.

Based on the data collected during this investigation, NIOSH investigators were unable to determine that a health hazard due to air contaminants existed at the time of the survey. Elevated CO_2 levels in two of the buildings did indicate that more fresh air needs to be added to the buildings' ventilation systems. Temperature and relative humidity measurements in three of the buildings were not within ASHRAE guidelines for thermal comfort. Recommendations are found in Section VI of this report to improve ventilation, thermal comfort and work practices.

KEYWORDS: SIC 9711 (National Security), SIC 3662 (Missle Control Systems), indoor air quality, formaldehyde, organic solvents, electronic repair, soldering.

II. BACKGROUND

In September 1987, NIOSH received a request from the Medical Department of the Naval Weapons Support Center, Crane, Indiana, to evaluate complaints of sore throat, headache, and fatigue among the occupants of two buildings on the site. The first area of concern was Building 121, a facility where electronic component fabrication, troubleshooting, repair, and testing are performed. Building 121 consists of an office area and shop area and is located above a cafeteria. In the shop area, soldering operations are performed at work benches without local exhaust ventilation. Spray painting is performed in a separate spray paint booth with an exhaust system vented directly to the outside.

The second area of concern was Building 2516, a general office building. Both buildings have been evaluated extensively by the staff industrial hygienists at Crane, and no cause for the symptoms had been found. Workers in Building 121 were also concerned about reports that three employees from that worksite had developed cancer over a 3-year period. A request was also received at the time of initial survey to evaluate potential formaldehyde exposures in Building 2958, a mobile home converted into office space. Environmental sampling in Building 41, another building where electronic component repair and testing are done, was also performed. Since there were no reported health complaints in Building 41, these air levels were obtained to provide additional information about potential air contaminant levels associated with soldering operations.

III. EVALUATION DESIGN AND METHODS

A. Medical

All available employees in Buildings 121 and 2516 were asked to complete a questionnaire, which sought information on demograhic characteristis, employment history, smoking and a variety of health symptoms. These symptoms were classified into three categories of frequency: 1) a little or not at all, 2) moderately (1-4 times/month), and 3) a lot (more than once a week). Workers were not asked to differentiate between symptoms at work or at home nor were they constrained by a specific time period.

B. Environmental

As part of this survey, industrial hygiene sampling was conducted in four buildings in this complex: Building 121, Building 41, Building 2958, a mobile home/trailer, and Building 2516. In Buildings 121 and 41, personal breathing zone and area air sampling for metal fumes was performed on or near workers operating soldering guns. Also, surface sampling for metals was performed at the soldering work stations in Building 121 to evaluate potential contamination of work surfaces with heavy metals since the walk-through evaluation had revealed evidence of eating, drinking

and smoking at the work stations. Area air sampling for formaldehyde, carbon dioxide (CO_2), and temperature and humidity measurements, was conducted in all four buildings. Hydrocarbon sampling was performed in order to assess any potential off-gassing from construction materials. The various sampling and analytical methods are described below.

Metals

Personal breathing-zone, area air, and surface/wipe sampling was performed according to NIOSH Method 7300.[1] In this method, sample air is drawn through a cellulose ester membrane filter using a calibrated, battery-powered pump. For surface sampling, filter paper was wetted with deionized water and wiped across the surface in question. Surface areas were wiped twice, in perpendicular directions. These samples were returned to the laboratory and analyzed for metals by inductively coupled plasma emission spectrometry. Using this method, one sample can be analyzed for 30 different metals. Detection limits varying by specific analyte.

Formaldehyde

Performance of area air sampling for formaldehyde was according to NIOSH Method 3500[1], which utilizes a midget impinger containing 20 milliliters (ml) of 1% sodium bisulfite solution. Air is sampled at a nominal flowrate of 1.0 liter per minute (lpm) through a calibrated, battery-powered sampling pump. After sampling, each impinger sample volume was measured, and a 4 ml aliquot taken for analysis. Color was developed by adding 0.1 ml of 1% chromotropic acid and 6 ml of concentrated sulfuric acid, and the samples were analyzed by visible spectroscopy. The limit of detection (LOD) is 0.6 micrograms per sample (ug/sample); the limit of quantitation (LOQ) is 1.8 ug/sample.

Carbon Dioxide

Carbon dioxide concentrations were measured using a Gastech Portable CO_2 Indicator, Model 3252. The measurement range for this meter is 0-10,000 ppm. The instrument was calibrated prior to use, using a CO_2 span gas.

Hydrocarbons

Aliphatic and aromatic hydrocarbons were measured using NIOSH Methods 1003, 1500, and 1503.[1] The air samples were collected by drawing air through a glass tube containing 150 milligrams of activated charcoal at a flowrate of 1.0 lpm (qualitative samples) and 0.2 Lpm (quantitative samples) using calibrated, battery-operated sampling pumps. The samples were desorbed with 1 ml of carbon disulfide and analyzed by gas chromatography (GC) with a flame ionization detector. Additionally, selected samples

were concentrated and analyzed by GC using a mass spectrometer for major compound identification.

Temperature and Relative Humidity

Temperature and relative humidity measurements were taken with a battery-powered psychrometer.

IV. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of air contamination criteria generally consulted include: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), (2) the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Values (TLVs), (3) the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limits (PELs), and (4) the indoor air quality standards developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The ASHRAE guidelines specify quantities of outside air to maintain acceptable indoor air quality, recommendations for the maintainance of thermal comfort, and

minimum ventilation rates which should be acceptable to the majority of human occupants and not impair health. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on

concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29USC 651, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Formaldehyde

Formaldehyde and other aldehydes may be released from foam plastics, carbonless paper, particle board, plywood, and textile fabrics. Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat and nose, headaches, nausea, congestion, skin rashes, and, in some individuals who may have developed hypersensitivity (allergy) asthma. It is difficult to ascribe specific health effects to specific concentrations of formaldehyde to which people are exposed, because individuals vary in their subjective responses and complaints. Irritation symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 parts per million (ppm), but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with pre-existing allergies or respiratory diseases, and persons who have become alergically sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. However, cases of formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are relatively uncommon.[2]

Formaldehyde vapor has been found to cause a rare form of nasal cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults as to whether or not formaldehyde is a carcinogen. Studies of long-term human occupational exposure to formaldehyde have not detected an increase in nasal cancer. Nevertheless, the animal results have prompted NIOSH to recommend that formaldehyde be handled as a potential occupational carcinogen. An estimate of the cancer risk to workers exposed to formaldehyde levels at or below 3 ppm has not yet been determined. NIOSH recommends that workplace exposures be reduced to the lowest feasible limit.[3] OSHA has recently reduced its occupational exposure limit (PEL) for formaldehyde to 1.0 ppm.[4]

The fact that formaldehyde is found in so many home products, appliances, furnishings, and construction materials has prompted several agencies to set standards or guidelines for residential formaldehyde exposure. ASHRAE has recommended, based on personal comfort, that exposure to formaldehyde be limited to 0.1 ppm. This guideline has also been adopted by NASA, and the Federal governments of Canada, West Germany, and the United Kingdom.[5] An indoor air formaldehyde concentration of less than 0.05 ppm (0.06 mg/m^3) is of limited or no concern according to the World Health Organization (WHO).[6]

Carbon Dioxide

Carbon dioxide, a normal constituent of exhaled breath can be meaured as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor, ambient concentration of CO_2 is usually 250 to 350 ppm. Typically the CO_2 level is higher inside than outside (even in buildings with few complaints about indoor air quality). However, if indoor CO_2 concentrations are more than 1000 ppm (3 to 4

times the outside level), there is probably inadequate outside air supply and symptoms such as headache, fatigue, and eye and throat irritation may result. Although the CO_2 itself is not responsible for these complaints, a high level of CO_2 does indicate that other contaminants in the building may also be increased.

The OSHA PEL and the ACGIH TLV for CO_2 is 5,000 ppm for an 8-hour TWA.[4,7] The NIOSH Recommended Exposure Level (REL) is 10,000 ppm for a 10-hour TWA.[8] These industrial limits, however, are not irrelevant, considering CO_2 levels commonly encountered in office buildings.

Temperature and Relative Humidity

The majority of references addressing temperature and humidity levels as they pertain to human health frequently appear in the context of assessing conditions in hot environments. Development of a "comfort" chart by ASHRAE presents a comfort zone considered to be both comfortable and healthful. This zone lies between 73° and 77°F (23° and 25°C) and 20 to 60 percent relative humidity.[9]

V. RESULTS

A. Medical

Seventy-two of the 100 (72%) current employees who were listed on the time sheet in Building 121 agreed to complete the self-administered questionnaire. Two individuals declined participation, and the remainder was on sick leave, vacation, on field assignments, or otherwise unavailable.

Thirty of the 44 individuals (68%) who were listed on an employee roster from Building 2516 agreed to complete the same questionnaire. The roster contained a listing of employees assigned to the facilities management division, work management branch, work generation branch, and planning and estimating branch.

The 72 participants in Building 121 were divided into two groups for comparison purposes. Since most of the electronic repair work such as soldering, painting, and gluing operation took place in the shop area of 121, individuals were grouped by location into the office area (23 employees) and shop area (48 employees). One individual's location could not be determined. This grouping was performed in order to assess the possibility that exposures from the various electronic repair or maintenance operations were responsible for the symptoms in the shop area.

1. Demographics:

The three study groups were of similar age. Building 121 employees had a higher proportion of men than Building 2516, expecially in the shop. Building 121 office workers had a lower proportion of smokers. Building 121 shop employees had a lower mean time in the building than the other 2 groups. The demographic characteristics of the three groups are found in Table 1.

2. Work Practices and Location Building 121:

Of the 72 Building 121 employees, 26 (36%) stated that their job included soldering operations. Solderers reported engaging in this operation for a mean of 13.7 hrs/week. Eighteen workers (25%) used various solvents for a mean of 9.4 hrs/week. Spray painting was reported by 14 workers (19%) for a mean time of 5.6 hrs/week. Twelve employees (16%) used glues an average of 2.4 hrs/week.

3. Medical History

The prevalences of self-reported, physician-diagnosed medical conditions are reported in Table 2. Workers in Building 121 with a family history of allergy were significantly more likely to report having allergies when compared to employees without such a family history (R.R. = 2.10, C.I. = 1.13 to 3.90, p = .01). This association between family history of allergy and reporting of allergies did not appear evident in Building 2516 workers.

4. Symptoms

Symptom prevalences are shown in Table 3. Comparisons of symptom occurrence between Building 121 office and shop employees are presented as relative risks.

When prevalence ratios of Building 121 office and shop workers were compared, no statistically significant differences were found for the study symptoms.

Adjustment of these relative risks for the effects of gender, smoking status, allergies, and hay fever revealed no differences. Therefore, only the unadjusted relative risks are reported.

5. Perception of the Environment

The results of questions about perception of the work environment are presented in Table 4.

In Building 121, the majority of employees 57 (79%) stated that they could smell "fumes" in the workplace. The following sources were identified by those who responded positively to the question: soldering: 34 (60%), spray painting: 27 (47%), kitchen fumes: 24 (42%), exhaust fumes: 22 (39%). Other sources were identified by 25 (44%) of workers. Building 2516 workers had fewer complaints about odors. Only five individuals (17%) reported smelling "fumes" in the environment.

Complaints of the temperature being too hot outnumbered complaints of too cold in all areas. Similarly, there were more complaints of high humidity that low humidity.

B. Environmental

Metals

Personal breathing-zone sampling for metals was performed on solder gun operators in Buildings 121 and 41, and three area samples for metals were taken in Building 121. Only one personal and one area sample in Building 121, and one personal sample in Building 41, had detectable metals; in each case there was only a trace level of magnesium (less than 0.008 milligrams per cubic meter of sample air).

The results from the surface sampling for metals are presented in Table 5. Surface sampling was performed on the work surfaces of five of the soldering work stations in Building 121. These samples indicate these work surfaces are contaminated with varying amounts of the following metals: aluminum, calcium, cadmium, copper, iron, magnesium, lead, nickel, sodium, tin, and zinc.

Formaldehyde

As shown in Table 6, formaldehyde concentrations in the four buildings were fairly consistent, ranging from 0.02-0.04 ppm. Even though these are between 6 and 10 times the measured outdoor ambient levels, it is not unusual to find these small amounts in buildings.

Carbon Dioxide

The carbon dioxide sampling data are presented in Table 7. The outdoor ambient CO_2 levels ranged between 300 to 350 ppm. Measured CO_2 levels in the buildings surveyed had the following ranges:

Building 121 - CO_2 concentrations ranged from 800 to 950 ppm, with an average level of 850 ppm. These are between 2 and 3 times higher than ambient levels.

Building 2516 - CO_2 concentrations ranged between 600 to 1500 ppm, with an average level of 958 ppm. Ten of these measurements were 1000 ppm or above. These levels are approximately 3 times higher the measured ambient levels.

Building 2958 - CO_2 concentrations ranged from 600 to 750 ppm, with an average concentration of 675 ppm. These levels are about 2 times higher than ambient levels.

Building 41 - CO_2 levels were not measured in this building.

Temperature and Relative Humidity

Temperature and relative humidity measurements taken in Buildings 121, 2516, and 2958 are shown in Table 7. On the survey date, dry bulb temperatures in the buildings surveyed were above the acceptable range for comfort, as defined by ASHRAE Standard 55-1981. Relative humidities in these buildings were between 38 and 52 percent and were within the comfort range.

Hydrocarbons

Tables 8-13 present the data from area sampling for hydrocarbons. In Building 121, very low concentrations of the following hydrocarbons were found: ethanol, toluene, n-butyl acetate, ethyl acetate, and 2-butoxy ethanol. The samples found virtually no variation in the concentration of the various analytes by sample location. Levels were from 800 to 7000 times lower than existing occupational exposure standards.

Isobutane, ethanol, acetone, and toluene were found in very low concentrations in Building 2958. The concentrations of these hydrocarbons varied little by sample location. The measured levels ranged from 500 to almost 4000 times less than the current occupational exposure limits.

Tables 10 and 11 present the concentrations of hydrocarbons found in Building 2516. Again, these levels were very low and varied little from sample to sample. It should be noted that NIOSH considers naphthalene and perchloroethylene to be potential human carcinogens and recommends that exposures be reduced to the lowest feasible level (LFL). The concentrations of the other hydrocarbons are from 900 to 7500 times lower than the current occupational exposure limits.

Finally, Tables 12 and 13 show the concentrations of hydrocarbons in Building 41. As in the other buildings, these levels are well below the current occupational exposure standards. It should be noted that exposure standards do not exist for ethylbutanol and ethylhexanol.

VI. CONCLUSIONS

A. There is no apparent difference in the prevalence of the study symptoms between office workers and shop workers in Building 121.

B. All study groups showed a higher prevalence of self-reported "allergies" than what is commonly reported in the medical literature. Many authors suggest that about 10% of the population has true "allergic disease" (atopy). Although regional variations in prevalence rates can be expected, it is not clear whether this rate reflects a true increased prevalence or a broader interpretation of what consitutes an allergy.

C. There is a strong association between having a family history of allergies and the reporting of allergies among the workforce of Building 121. This association was not seen in Building 2516.

D. The industrial hygiene data did not suggest a specific common exposure source in either building that could provide an etiologic explanation for the most commonly reported symptoms. However, the high temperatures and CO_2 levels found in Buildings 121, 2516 and 2958 are indicative of poor ventilation. Some of the symptoms reported here are often seen in indoor office environments with inadequate ventilation.

E. The question of cancer incidence among the workforce could not be addressed due to the difficulty in obtaining specific medical records. However, the three supplied diagnoses are different in location and cell type and do not suggest a cancer cluster due to a common etiology.

VII. RECOMMENDATIONS

A. Medical

Since the data suggest that no single agent or work activity is responsible for the symptoms among the workforce, no further group medical screening is suggested at this time.

Individuals with symptoms suggestive of allergic disease should have standard medical evaluations to determine the cause and any potentially aggravating factors.

B. Environmental

These recommendations are being made based on the conditions encountered during the NIOSH survey:

1. No eating, drinking, or smoking should be allowed in areas where soldering is taking place. The surface sampling in Building 121 found metal contamination in these areas, increasing the possibility of ingestion of these metals as a result of contamination of tobacco products and/or food.

2. The large number of CO_2 measurements near or above 1000 ppm in Building 2516, and the number of measurements near this level in Building 121, indicate that an increase is needed in the amount of outside air added to the ventilation systems in these buildings. Increasing the amount of outside air added to the ventilation system would also be expected to decrease the airborne concentrations of contaminants.

3. The temperature in Buildings 121, 2516, and 2958 should be adjusted so that it falls within ASHRAE's comfort range of 73° and 77°F (23° and 25°C).

VIII. REFERENCES

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X. Distribution and Availability of Report

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. AFGE - Local 1415
2. Medical Department - U.S. Naval Weapons Suport Center, Crane, IN
3. Indiana State OSHA
4. OSHA - Region X

Table 1

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Demographics: Study Groups

	Building 121	121 shop	121 office	Building 2516
Number	72	48	23	30
Mean age (s.d)*	39 (9.9)	40 (9.9)	37 (9.9)	40 (10.4)
Males	54 (72%)	40 (83%)	14 (61%)	15 (50%)
# smokers	27 (38%)	19 (39%)	7 (21%)	12 (40%)
Mean years in bldg(s.d.)	4.2 (3.2)	3.8 (3.3)	5.0 (3.1)	5.2 (4.6)

* standard deviation

Table 2
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Self Reported Medical Histories
Building 121 and Building 2516

	Building 121	Building 2516
Number	72	30
Allergy	33 (46%)	10 (33%)
Asthma	8 (11%)	3 (10%)
Food or drug allergy	18 (25%)	8 (27%)
Dust allergy	20 (28%)	11 (37%)
Hay fever	20 (28%)	8 (27%)
Eczema	5 (7%)	4 (13%)
Family History of allergies	29 (40%)	7 (23%)

Medical History: Building 121 Shop vs. Office

	121 Shop	121 Office	RR.**1**	**C.I.**2	p value
Number	48	23			
Allergy	20 (42%)	12 (52%)	.78	(.47, 1.29)	NS[3]
Asthma	6 (13%)	2 (9%)	1.36	(.30, 6.18)	NS
Food or drug allergy	13 (27%)	4 (17%)	1.44	(.54, 3.88)	NS
Dust allergy	13 (27%)	6 (26%)	1.01	(.45, 2.26)	NS
Hay fever	12 (25%)	7 (30%)	.86	(.40, 1.85)	NS
Eczema	1 (2%)	4 (17%)	8.0	(.96, 66.72)	NS
Family History of allergies	17(35%)	11 (48%)	.75	(.45, 1.27)	NS

1 - relative risk for office compared to shop
2 C.I. - 95% Confidence Interval
3 Not Significant ($p > 0.05$)

Table 3

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Symptom Prevalence +

Building 121 Shop Compared to Office

Symptom	Shop	Office	R.R.(shop/office)[1]	C.I.[2]	p value
Number	48	23			
headache	30 (66%)	11 (50%)	1.30	(.82, 2.08)	NS[3]
sneezing	29 (63%)	15 (68%)	.92	(.64, 1.33)	NS
nasal drip	23 (50%)	10 (45%)	1.10	(.64, 1.89)	NS
eye irritation	25 (53%)	10 (45%)	1.17	(.69, 1.99)	NS
sinus congestion	25 (54%)	14 (64%)	.85	(.57, 1.29)	NS
tiredness	30 (64%)	14 (64%)	1.0	(.68, 1.47)	NS
sore throat	21 (45%)	7 (32%)	1.35	(.67, 2.69)	NS
cough	21 (46%)	6 (29%)	1.60	(.76, 3.37)	NS
short of breath	10 (22%)	5 (24%)	.91	(.36, 2.34)	NS
rash	7 (16%)	0	7.3 *	(.74, 71.8)	NS

*estimate obtained by adding 0.5 to each cell

Symptom Prevalence Building 2516

Symptom	2516
number	30
headache	14 (48%)
sneezing	11 (41%)
nasal drip	9 (32%)
eye irritation	7 (26%)
sinus congestion	13 (46%)
tiredness	13 (48%)
sore throat	5 (19%)
cough	5 (19%)
short of breath	6 (22%)
skin rash	1 (4%)

+ Prevalence of persons reporting that the symptom occurs "moderately" or "a lot" (versus "not at all" or "a little".

1 Relative risk
2 C.I. 95% confidence interval
3 Not Significant

Table 4

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Environmental Factors

	121 total	121 shop	121 office	2516
Temp				
too hot	31 (43%)	24 (50%)	6 (26%)	4 (13%)
too cold	3 (4%)	1 (2%)	2 (9%)	0
comfortable	36 (50%)	21 (44%)	15 (65%)	25 (83%)
Humidity				
too high	24 (33%)	16 (33%)	7 (30%)	4 (13%)
too low	6 (8%)	5 (10%)	1 (4%)	1 (3%)
comfortable	41 (57%)	26 (54%)	15 (65%)	24 (80%)
Smell Fumes:				
Yes	57 (79%)	41 (85%)	16 (70%)	5 (17%)
No	14 (19%)	7 (15%)	7 (30%)	24 (80%)

Table 6

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Area Sampling for Formaldehyde

Sample Location	Sample Time	Sample Volume[1]	Conc.- ppm[2]
Building 121-2nd Floor Office	1045-1545	225	0.02
Building 121-2nd Floor Repair	1046-1512	250	0.02
Building 121-2nd Floor Repair	1048-1512	251	0.02
Building 121-2nd Floor Repair	1047-1512	248	0.02
Building 121-2nd Floor Repair	1106-1507	228	0.03
Building 121-Roof	1035-1522	237	0.003
Building 121-Roof	1035-1522	247	0.003
Building 2958-Trailer	1138-1448	181	0.04
Building 2958-Trailer	1137-1448	172	0.04
Building 2958-Trailer	1139-1449	181	0.04
Building-Copier	1120-1647	292	0.03
Building 2516-Blueprint Machine	1118-1647	287	0.03
Building 2516-Telecommunication	1121-1625	277	0.04
Building 41-Adate 1510	1103-1511	236	0.02
Building 41-Test Station	1102-1514	239	0.02

NIOSH REL	LFL[3]
OSHA PEL	1.0
ACGIH TLV	1.0
ASHRAE	0.1

LOD: 0.6 ug/sample
LOQ: 1.8 ug/sample

[1] Units expressed in liters of air.
[2] Units expressed in parts per million of formaldehyde.
[3] LFL-Lowest Feasible Limit.

Table 7

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Indoor Air Quality Data

Sample Location	Sample Time	Concentration[1]	Psychrometry	
			DB[2]	RH[3]
Building 121, 2nd Floor	1255	900	78	47
Building 121, 2nd Floor	1300	800	75	52
Building 121, 2nd Floor	1305	800	80	45
Building 121, 2nd Floor	1310	900	80	45
Building 121, 2nd Floor	1315	800	77	50
Building 121, 2nd Floor	1316	900	78	40
Building 121, 2nd Floor	1318	800	75	52
Building 121, 2nd Floor	1320	950	79	45
Building 121, 2nd Floor	1322	800	79	45
Outside, Ambient Air	1345	300	94	26
Outside, Ambient Air	1435	350	94	28
Outside, Ambient Air	1500	300	94	28
Building 2516	1350	1000	-	-
Building 2516	1352	1000	80	42
Building 2516	1353		-	-
Building 2516	1355	1000	78	46
Building 2516	1358	1500	-	-
Building 2516	1358	1200	79	45
Building 2516	1400	1000	-	-
Building 2516	1400	622	77	45
Building 2516	1410	-	-	-
Building 2516	1425	-	-	-
Building 2958	1445	-	79	38
Building 2958	1445	600	-	-
Building 2958	1450	750	79	38
Building 2958	1450	750	-	-

[1] Values expressed in parts per million of carbon dioxide.
[2] DB - dry bulb temperature in degrees Fahrenheit.
[3] RH - percent relative humidity.

Table 5

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Surface Sampling for Metals, Building 121

Metal Analyte[1]	LOD[2]	Range of Levels[3]
Aluminum	10	11-35
Calcium	5	25-120
Cadmium	1	1-7
Copper	1	2-39
Iron	1	10-370
Magnesium	1	3-13
Lead	2	16-170
Nickel	1	1-7
Sodium	50	52-150
Tin	10	11-77
Zinc	1	7-36

1 Surface samples were analyzed for 30 metals. The listed metals are those found on these samples.

2 LOD - Limit of Detection for this method in micrograms per surface sample.

3 Surface sampling was performed on the work surfaces for the soldering stations. These values represent the range (minimum-maximum) of levels, in micrograms, found at the soldering stations.

Table 8

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Area Air Sampling for Hydrocarbons in Building 121

Sample Location	Sample Time	Sample Volume[1]	Ethanol[2]	Toluene[2]	n-Butyl Acetate[2]	Ethyl Acetate[2]	2-Butoxy Ethanol[2]
Sonar Production 70423	0923-1512	349	0.15	0.04	0.06	0.08	0.06
Sonar Production 70423	0925-1513	383	0.14	0.04	0.06	0.07	0.05
Sonar Production 70423	0924-1512	348	0.15	0.04	0.06	0.08	0.06
Sonar Production 70423	0924-1512	348	0.15	0.04	0.06	0.08	0.06
Sonar Production 70423	0923-1512	349	0.15	0.04	0.06	0.08	0.06
OSHA PEL			1000	200	200	400	50
NIOSH REL			-	100	-	-	-

[1] Unit expressed in liters of air.
[2] Units expressed in parts per million

Table 9

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Area Sampling for Hydrocarbons in Building 2958

Sample Location	Sample Time	Sample Volume[1]	Isobutane[2]	Ethanol[2]	Acetone[2]	Toluene[2]
Near Bidboard	1139-1449	196	0.17	0.27	0.22	0.07
Near Middle of Trailer	1138-1448	190	0.17	0.28	0.22	0.07
Back Portion of Trailer	1137-1448	191	0.17	0.28	0.22	0.07
OSHA PEL			100	1000	1000	200
NIOSH REL			-	-	250	100

[1] Unit expressed in liters of air.
[2] Units expressed in parts per million

Table 10

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Area Air Sampling for Hydrocarbons in Building 2516

Sample Location	Sample Time	Sample Volume[1]	1,1,1,-Trichloroethane[2]	Xylene[2]	2-Butoxy Ethanol[2]	Perchloroethylene[2]	Naphthalene[2]
Telecommunications Area	1121-1625	319	0.06	0.07	0.06	0.04	0.06
Copier Area	1120-1627	330	0.06	0.07	0.06	0.04	0.06
Blueprinting Area	1118-1628	318	0.06	0.07	0.06	0.04	0.06
OSHA PEL			350	100	50	100	10
NIOSH REL			350	100	-	LFL[3]	LFL[3]

[1] Units expressed in liters of air.
[2] Units expressed in parts per million
[3] Lowest Feasible Level.

Table 11

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Area Air Sampling for Hydrocarbons in Building 2516

Sample Location	Sample Time	Sample Volume[1]	Toluene[2]	Acetone[2]	Isopropanol[2]	MEK[2]	MIBK[2]	n-Butyl Acetate[2]
Telecommunications Area	1121-1625	319	0.08	0.13	0.13	0.10	0.07	0.06
Copier Area	1120-1627	330	0.08	0.13	0.13	0.10	0.07	0.06
blueprinting Area	1118-1628	318	0.08	0.13	0.13	0.10	0.07	0.06
OSHA PEL			200	1000	400	200	100	200
NIOSH REL			100	250	400	200	50	-

[1] Units expressed in liters of air.
[2] Units expressed in parts per million

Table 12

HETA 87-411
Naval Weapons Support Center
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June 7, 1988

Area Sampling for Hydrocarbons in Building 41

Sample Location	Sample Time	Sample Volume[1]	Isopropanol[2]	Isobutyl Acetate[2]	Isobutanol[2]	MEK[2]	Toluene[2]
Adate Test Station	0923-1512	349	0.12	0.06	0.09	0.09	0.08
Exciter Receiver	1017-1515	298	0.14	0.07	0.11	0.11	0.09
Adate Test Station	1102-1512	250	0.16	0.08	0.13	0.14	0.11
ALQ-99 Area	0952-1508	316	0.13	0.07	0.10	0.11	0.08
OSHA PEL			400	150	100	200	200
NIOSH REL			400	-	-	200	100

[1] Units expressed in liters of air.
[2] Units expressed in parts per million of given contaminants.

Table 13

HETA 87-411
Naval Weapons Support Center
Crane, Indiana
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Area Air Sampling for Hydrocarbons in Building 41

Sample Location	Sample Time	Sample Volume[1]	1,1,1-Trichloroethane[2]	Ethylbutanol[2]	Ethylhexanol[2]	Xylene[2]
Adate Test Station	0923-1512	349	0.05	0.07	0.05	0.07
Exciter Receiver	1017-1515	298	0.06	0.08	0.06	0.08
Adate Test Station	1102-1512	250	0.07	0.10	0.08	0.09
ALQ-99 Area	0952-1508	316	0.06	0.08	0.06	0.07
OSHA PEL			350	-	-	100
NIOSH REL			350	-	-	100

[1] Units expressed in liters of air.
[2] Units expressed in parts per million of given contaminants.